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Commander
U.S. Army White Sands Missile Range
ATTN: CSTE-DTC-WS-ST-AA
White Sands Missile Range, NM 88002-5157

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9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Commander
U.S. Army Developmental Test Command
ATTN: CSTE-DTC-TT-M
314 Longs Corner Road
Aberdeen Proving Ground, MD 21005-5055

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This TOP provides guidance for determining the ability of equipment under test to operate and the ability of the equipment materiel to withstand exposure to various temperature-altitude environments. Temperature-altitude tests are one of a series of possible environmental tests conducted to ensure the reliability of a missile system. The tests described herein include the probable extreme temperature-altitude conditions to which a missile system may be exposed. In addition, these tests will permit determination of materiel degradation, if any. The range of environmental conditions is not limited to those of the intended tactical emplacement of the equipment, but includes those which might be encountered during the item's life cycle including transportation and storage (without protective packaging).

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TEMPERATURE-ALTITUDE TESTS FOR MISSILE SYSTEM AND MISSILE SUBSYSTEM EQUIPMENT

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1. SCOPE.

a. This TOP provides guidance for determining the ability of equipment under test (the test item) to operate and the ability of the equipment materiel to withstand exposure to various temperature-altitude environments.

b. Temperature-altitude tests are one of a series of possible environmental tests conducted to ensure the reliability of a missile system. The tests described herein include the probable extreme temperature-altitude conditions to which a missile system may be exposed. In addition, these tests will permit determination of materiel degradation, if any. The range of environmental conditions is not limited to those of the intended tactical emplacement of the equipment, but includes those which might be encountered during the item's life cycle including transportation and storage (without protective packaging).

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c. The following items shall not be tested in the environmental test facility:

(1) Items containing explosive or highly flammable material, unless the test is to be conducted in an area approved specifically for the testing of the aforementioned items.

(2) Items not capable of being transported by readily available means.

(3) Items of such size capable of affecting or limiting the ability of the environmental facility to achieve or maintain the desired environmental conditions.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

a. The required test apparatus consists of a chamber or cabinet and auxiliary instrumentation capable of maintaining and continuously monitoring temperature, humidity, and pressure. (Note: More than one chamber may be required to meet the requirements based on temperature and pressure ranges.) The chamber shall be capable of providing air temperatures between -62°C and 100°C (-80°F and 212°F). The temperature rate of change shall not exceed 1°C/sec (3°F/sec) and the chamber air velocity in the vicinity of the test item shall not exceed 1.7 m/s (335 ft/min) unless justified by the test item platform environment. (Note: This air velocity value prevents unrealistic heat transfer to and/or from the test item in an ambient pressure environment, i.e., greatly enhances the transfer of heat/cold to all parts of the test item.) The chamber shall also be capable of providing an altitude simulation within the probable pressure extremes of those normally encountered near sea level (or chamber site altitude) to those normally encountered at or beyond 30,500 m (100,000 feet), with an equivalent altitude (low pressure) rate of change that shall not exceed 500 m/s (100,000 ft/min). (Note: A test may require a sub-sea level pressure, thus the selected chamber may require this capability.) The chamber shall be appropriately sized to contain the test item and it should have a blower which swirls any test item discharge to provide turbulent airflow during tests conducted at or near ambient pressure.

2.2 Instrumentation.

Devices for Measuring	Permissible Measurement Tolerance
Pressure	± 1 percent (of reading)
Temperature	± 2 °C
Relative Humidity	± 5 percent

2.3 Accuracy. Verify the accuracy of all instruments and test equipment prior to and following each test (the accuracy shall be at least one-third the tolerance for the variable to be measured). All measuring devices shall be calibrated in predetermined intervals to laboratory standards whose calibration is traceable to the National Standards via primary standards.

3. REQUIRED TEST CONDITIONS.

3.1 Test Planning.

a. Table 1 presents a list of possible test environments, temperature versus pressure (altitude), that might be encountered by the test item during its life cycle. The operational status of the test item, as related to the various environments, is also shown.

b. Review previous test reports of similar test items to check for recommended test procedure modifications. Further guidance may be found in Military Standard (MIL-STD)-810F[1*], (establishes generally applicable procedures for testing equipment under simulated and accelerated environmental conditions) and MIL-STD-1540D[2] (establishes the environmental and structural ground testing requirements of flight vehicles).

c. Select the test procedure to be implemented. Combined testing is encouraged.

d. The specific test sequence and content shall be developed or tailored by the test engineer using additional guidance provided in MIL-STD-810F. Tailoring is defined as: ". . . the process of choosing or altering test procedures, conditions, values, tolerances, measures of failures, etc., to simulate or exaggerate the effects of one or more forcing functions to which an item will be subjected during its life cycle . . .".

(1) Experience has shown definite advantages to performing certain tests immediately before, in combination with, or immediately following other tests. For example, a low-pressure test is considered to be the least damaging test for many types of equipment, therefore, it may be one of the first to be conducted in a particular environmental test sequence; whereas a low- or high-temperature test is considered to be a slightly more damaging test and, therefore, may be performed later in a particular test sequence. The chosen environmental test sequence should attempt to duplicate environments to which equipment is subjected during transit, storage, or operational deployment, if possible. Additionally, experience has shown that the combined temperature-altitude type test should be conducted at the end or near the end of the chosen environmental test sequence or at least before final equipment designs are finalized.

*Superscript numbers on references correspond to those listed in Appendix D, References.

TABLE 1. POSSIBLE TEST ENVIRONMENTS

Class*	Equipment Mode		Temperature(°C)	Altitude(m)** (Atmospheric Pressure[kPa])
	Continuously Operating	Non-operating		
1	X ----------	---------- X	-54 to - 55 ---------- -62 to - 85	Sea level to 15,240 (11.6)
2	X ----------	---------- X	-54 to - 71 ---------- -62 to - 95	Sea level to 21,335 (4.4)
3	X ----------	---------- X	-54 to - 95 ---------- -62 to - 150	Sea level to 30,500 (1.1)
4	X ----------	---------- X	-54 to - 125 ---------- -62 to - 260	Sea level to 30,500 (1.1)

NOTES:

*The classes of equipment identified in Table 1 are established for illustrating the equipment operating-mode - temperature-altitude relationship only. The term "class" is not used for any other purpose herein.

**Refer to Appendix C, Figure C-1, for mathematical process to convert from altitude in meters to pressure in kPa or reverse.

(2) Examples of some of the effects that can occur as a result of exposure to reduced pressure are:

(a) Leakage of gases or fluids from gasket-sealed enclosures.

(b) Rupture or explosion of sealed containers.

(c) Change in physical and chemical properties of low-density materials.

(d) Overheating of equipment due to reduced heat transfer.

(e) Failure of hermetic seals.

(3) Examples of some of the effects that can occur as a result of exposure to low or high temperature are:

(a) Hardening and embrittlement of materials.

(b) Binding of parts from differential contraction or expansion of dissimilar materials and the different rates of contraction or expansion of different parts in response to temperature transients.

(c) Changes in electronic components. Electronic circuit stability varying with differences in temperature gradients and differential expansion of dissimilar materials.

(d) Cracking, crazing, and reduced strength.

(e) Condensation and freezing of water.

(f) Altering of operating/release margins on relays and magnetic or thermally activated devices.

(g) Shortened operating lifetime.

3.2 Test Preparation. Visually inspect the test item and note any existing damage.

3.2.1 Equipment Pre-Test Operation.

a. Prior to conducting any tests, the test item should be operated at standard ambient conditions, defined below, to obtain and document data determining compliance with the requirements document(s) and for comparison with data obtained before, during, and after the environmental test(s).

Temperature of 25°C ± 10°C (77°F ± 18°F)
Atmospheric pressure of the local test site
Relative humidity of 50% ± 30%

b. The environmental test history of the specific test item(s) should be documented for failure analysis purposes. All functional parameters as specified in the test item's test plan or

environmental test instruction sheet (an example of which is provided in Appendix A) should be documented. These data shall be used as a standard or baseline for comparing data recorded during and after the environmental tests.

3.2.2 Preparation of the Environmental Test Chamber.

a. Arrange the test chamber and auxiliary equipment to avoid the following:

(1) Condensate dripping on the test item.

(2) Radiant heat directed on the test item (when used as a heat source).

b. Locate instrumentation equipment as follows:

(1) Pressure monitoring transducer(s) - Rigidly attach the transducer(s) to the test item or the chamber wall as required in the test plan using appropriate fixtures.

(2) Relative humidity transducer(s) - Locate at the mouth of one of the chamber's common air inlet ducts.

(3) Thermocouples (or equivalent temperature sensors) - Locate where they shall not be in a direct line with either incoming temperature controlled air or radiant elements. Consider the following when determining sensor locations:

(a) Air or skin temperature shall be measured at several interior and exterior points for each major unit of the test item. Equipment heat produced during operation must be considered when selecting the sensor location.

(b) Skin temperature(s) on the component(s) where the highest operating temperature is expected in accordance with (IAW) the test plan.

(c) Skin temperature(s) on the component(s) whose temperature rise or fall is critical and is likely to limit equipment performance IAW the test plan.

3.3 Conduct of Test.

a. Whenever practical, specific test condition levels, ranges, rates, and durations shall be derived from field measurements made on actual or appropriately similar equipment.

b. If damage occurs to the test item which effects the operational status of the test item, it should be repaired, at least to the extent that normal operation is restored, prior to continuing the test.

c. Test item temperature stabilization is defined/attained, unless otherwise specified, when the temperature of the operating part of the test item considered to have the longest thermal lag (1) is changing no more than 2°C (3.6°F) per hour [test item operating] or (2) reaches a temperature within test tolerances of the nominal test temperature, except that any critical component (e.g., elevon actuation electronics) will be within 1°C (1.8°F) [test item non-operating].

d. An example of a test sequence plan along with an example of associated general test procedures are provided in Appendix B.

(1) Table B-1 in Appendix B describes a specific sequence of test conditions (or test steps) and includes links to the test item's operational status. Two example procedures are provided to illustrate two given sets of conditions (or steps). Each set of test conditions listed in Table B-1, Appendix B represents a condition which the test item may encounter in service. Therefore, each test may be applied independently of each other.

(2) In addition to the general guidance provided in MIL-STD-810F and in Appendix B, the test director can select other test points/conditions which may be derived from Figures B-1 through B-4 in Appendix B representing various operational requirements of the representative equipment classes.

4. TEST PROCEDURES.

The following procedures are performed in preparation for, or performed during flight or operational testing. Tailoring is highly recommended. The purpose of the recommended procedures is to use laboratory testing in lieu of flight testing to quickly evaluate environmental problems discovered in flight testing (as opposed to actual flight). These tests are not accelerated, i.e., the damage accumulation potential is the same as in operational or flight testing. Therefore, development hardware can be interchanged between laboratory and flight or operational testing. When unusual problems develop in flight or operational testing, the materiel can be brought into the laboratory to help identify any environmental contribution to the observed problem. In general, a single cycle is adequate to verify problems. Each procedure can easily be converted to a multi-cycle process, which is defined as a controlled repetition of a selected altitude (fixed or variable) and temperature (fixed or variable), either separate or combined test procedures. If the test plan does not require repeated cycles or only requires selected steady-state test levels, proceed accordingly.

4.1 General Test Requirements. The following general procedural elements are provided as guidance. Refer to MIL-STD-810F for additional planning and implementation guidance.

a. Determine the mission profile (the operational parameters for the test item based on its anticipated deployment mission), test altitude (or test altitude range), test temperature (or test temperature range), altitude rate of change (increase or decrease), temperature rate of change, if applicable, duration of exposure (a period that is considered representative of the anticipated service environment, either repeated or cyclic), test item configuration, and any other appropriate condition(s) IAW the test plan, requirements documents or the life cycle environmental profile. Prepare an environmental test instruction sheet (see example provided in Appendix A).

b. Establish or verify the test controls:

(1) Unless otherwise specified, the altitude rate of change shall not exceed 500 m/s (100,000 ft/min) and the temperature rate of change shall not exceed 1°C/sec (3°F/sec). Also, while at ambient pressure, if any action other than test item operation (such as opening the chamber door) results in a significant change of the test item temperature (more that 2°C [3.6°F]) or chamber air temperature, re-stabilize the test item at the required temperature before continuing the test. If the operational check is not completed within 15 minutes, re-establish test item temperature conditions before continuing.

(2) Continuous recordings of chamber pressure and temperature shall be taken as required.

c. Establish test interruption criteria:

(1) Pressure (altitude) undertest/overtest interruptions - To achieve the desired effects, the test item must be subjected to the low-pressure (altitude) environment without interruption.

(a) A deviation of more than 10 percent of the measured value toward ambient atmospheric conditions shall be followed by a repeat of the entire test if desired or a continuation of the test from the point of deviation once conditions are brought back to nominal (if this occurs, see note in next paragraph below).

(b) A complete physical examination and operational check, where possible, should be conducted. Any evidence of deterioration should result in a retest, after test item repair/replacement. Re-initiation of the entire test with a new test item is allowed. If no deterioration is detected, the entire test shall be repeated. Any interruption must be carefully analyzed. If a decision is made to either continue testing from the point of interruption, or to restart the last successfully completed test cycle, or to restart the entire test with the same test item and a failure occurs, it is essential to consider the possible effect of the interruption, or of the extended length of the test on the test item.

(2) Temperature undertest (cycling) interruptions - If an unscheduled interruption occurs that causes the test conditions to fall out of allowable tolerances, the test must be reinstated at the end of the last successfully completed cycle.

(3) Temperature undertest (steady-state) interruptions - If an unscheduled interruption occurs that causes the test conditions to fall out of allowable tolerances, the test item shall be re-stabilized at the required test temperature and the test continued from the point where the test conditions deviated from the plan.

(4) Temperature overtest interruptions - Any interruption in a cyclic or steady-state test that results in more extreme exposure of the test item than required by the equipment specifications should be followed by a complete physical inspection and an operational check, where possible, before continuation of testing. If no problem is encountered, reestablish pre-interruption conditions and continue from the point where the test tolerances were exceeded.

d. Test item failure interruptions - Review test item failure analysis criteria and understand the requirements for test information. Test item failure and subsequent test item repair or replacement shall be followed by a repeat of the entire test IAW the test plan and environmental test instruction sheet. If the test is multi-cycle in nature, the test may be restarted from the point of the last successfully completed test cycle after a careful analysis of the failure condition is completed. Failure of the test item to meet any one of the following conditions shall constitute a test item failure.

(1) Deviation of monitored functional parameter levels beyond acceptable limits established in the test plan and requirements document.

(2) Non-fulfillment of safety requirements or the development of safety hazards.

(3) Non-fulfillment of specific test item requirements.

(4) Changes to the test item, which could prevent the equipment from meeting its intended service life or maintenance requirements, e.g., a service port jam that cannot be opened with service tools.

(5) Other failure criteria specified in the equipment specification.

4.2 Fixed Altitude (Low Pressure) At Ambient Temperature Test.

4.2.1 A fixed or constant altitude chamber test conducted at ambient temperature is used to determine the performance of the test item or its materiel under low-pressure conditions.

4.2.2 The following steps, alone or in combination, provide the basis for collecting necessary information concerning the materiel in a low-pressure environment. Unless otherwise specified, maintain the chamber temperature at standard ambient.

a. Execute a pre-test standard ambient checkout.

(1) Set up or install the test item in the test chamber at ambient pressure and temperature in a manner that will simulate usage and connections made as necessary IAW the test plan and instruction sheet.

(a) Plugs, covers, and inspection plates not used in operation, but used in servicing, shall remain in place.

(b) Electrical connections normally used in service, but not in test, shall be provided with electrical connectors having dummy cables with protected terminations. Such mechanical connections shall also be protected.

(c) The test item shall be operated according to the applicable technical order or technical manual, when available, or IAW the item's normal operating parameters to determine that no damage or malfunction has resulted from faulty installation or handling. The requirement to operate the test item after its installation in the test chamber applies only when the item is required to operate during the test. Document all operating parameters as specified in the test item's test plan.

(d) Test items shall be positioned at least 15 cm (6 inches) from each other or from walls, floors, ceilings, etc., to allow for adequate circulation.

(e) If the item to be tested consists of several separate units, these units may be tested separately provided the functional aspects are maintained as defined in the requirements document.

(2) Install temperature sensors in, on, or around the test item as described in the test plan or in the environmental test instruction sheet (an example of sensor location is presented in Appendix A, Figure A-2). Pressure and relative humidity transducers are installed as specified in the test plan.

(3) Conduct a visual examination of the test item with special attention to stress areas, such as corners of molded cases, and document the results.

(4) Conduct an operational checkout as described in the test plan and record the results. Use functional parameters and operational limits specified in the materiel specification or requirements document.

(5) If the test item operates satisfactorily, proceed to the next test procedure phase.

b. Execute a storage/transit test procedure. If this test is not required, skip to paragraph 4.2.2c below.

(1) Place the test item in its storage configuration, if different than its operational configuration, and reinstall it into the test chamber.

(2) If appropriate, stabilize the test item to the required ambient pressure and ambient temperature test conditions.

(3) With the test item non-operating, adjust the chamber from the site ambient pressure to the storage/transit test pressure (altitude). Perform the pressure ramp at the maximum altitude rate of change unless otherwise specified in the test plan. An example of a typical low-pressure test cycle is presented in Appendix A, Figure A-2.

(4) Maintain the conditions for a minimum of 1 hour unless otherwise specified in the test plan.

(5) Adjust the chamber test pressure and test temperature to standard ambient conditions at the rate specified in the test plan.

(6) Visually examine the test item to the extent possible and conduct an operational checkout IAW the test plan. Document the results.

c. Execute an operational test procedure.

(1) Place the test item in its operational configuration within the test chamber.

(2) If appropriate, stabilize the test item to the required ambient pressure and ambient temperature test conditions.

(3) With the test item non-operating, adjust the chamber from the site ambient pressure to the required equivalent operational test pressure (altitude) at a rate not to exceed that specified in the test plan. An example of a typical low pressure test cycle is presented in Appendix A, Figure A-2.

(4) Conduct an operational checkout of the test item IAW the requirements documents and document the results.

(5) Adjust the chamber test pressure and test temperature to standard ambient conditions at the rate specified in the test plan.

(6) Visually examine the test item to the extent possible and conduct an operational checkout. Document the results.

d. Execute a post-test standard ambient checkout.

(1) Adjust the chamber test pressure and test temperature to standard ambient conditions at the rate specified in the test plan.

(2) Conduct a visual examination of the test item with special attention to stress areas and document the results.

(3) Conduct an operational checkout as described in the test plan and document the results.

(4) Secure the test item and remove it from the test chamber IAW the test plan.

4.2.3 Repeat the above procedural steps, paragraph 4.2.2a through 4.2.2d, as appropriate to perform a multi-cycle test, if required, IAW the test plan. Document the results.

4.3 Combined Variable Altitude - Temperature Test.

4.3.1 A variable altitude chamber test conducted at either low or high temperature (non-ambient) is used to determine the performance of the test item or its materiel under both low-pressure and thermally-stressed conditions.

4.3.2 The following steps, alone or in combination, provide the basis for collecting necessary information concerning the materiel in a combined low-pressure and low/high-temperature environment.

a. Execute a pre-test standard ambient checkout.

(1) Set up or install the test item in the test chamber at ambient pressure and temperature in a manner that will simulate usage and with connections made as necessary IAW the test plan and instruction sheet.

(a) Plugs, covers, and inspection plates, not used in operation but used in servicing, shall remain in place.

(b) Electrical connections normally used in service, but not in test, shall be provided with electrical connectors having dummy cables with protected terminations. Such mechanical connections shall also be protected.

(c) The test item shall be operated according to the applicable technical order or technical manual, when available, or IAW the item's normal operating parameters to determine that no damage or malfunction has resulted from faulty installation or handling. The requirement to operate the test item after its installation in the test chamber applies only when the item is required to operate during the test. Document all operating parameters as specified in the test item's test plan.

(d) Test items shall be positioned at least 15 cm (6 inches) from each other or from walls, floors, ceilings, etc., to allow for adequate circulation.

(e) If the item to be tested consists of several separate units, these units may be tested separately provided the functional aspects are maintained as defined in the requirements document.

(2) Install temperature sensors in, on, or around the test item as described in the test plan. Pressure and relative humidity transducers are installed as specified in the test plan.

(3) Conduct a visual examination of the test item with special attention to stress areas, such as corners of molded cases, and document the results.

(4) Conduct an operational checkout as described in the test plan and record the results. Use functional parameters and operational limits specified in the materiel specification or requirements document.

(5) If the test item operates satisfactorily, proceed to the next test procedure phase.

b. Execute a storage/transit test procedure. If this test is not required, skip to paragraph 4.3.2c below.

(1) Place the test item in its storage configuration, if different than its operational configuration, and reinstall it into the test chamber.

(2) If appropriate, stabilize the test item to the required low test temperature and ambient pressure. If not appropriate, skip to paragraph 4.3.3b(7).

(a) With the test item non-operating, ramp the chamber temperature from room ambient conditions down to the minimum storage/transit test temperature. Two visual examples are presented in Appendix A to describe: (1) a ramp from ambient temperature to a low-test temperature (Figure A-3) and (2) a diurnal low temperature test cycle (Figure A-4). These examples are presented as information only.

(b) Allow the test item to soak at the minimum storage/transit test temperature until it has reached thermal stabilization or for 4 hours, whichever is shorter.

(3) Ramp the chamber from the site ambient pressure to the storage/transit low-test pressure (altitude). Perform the pressure ramp at the maximum altitude rate of change unless otherwise specified in the test plan. A visual example of a typical low-pressure test cycle is presented in Appendix A, Figure A-2. Note: Chamber pressure and temperature can be varied as required in the test plan either independently or dependently.

(4) Maintain the conditions for a minimum of one hour unless otherwise specified in the test plan.

(5) Adjust the chamber test pressure and test temperature to standard ambient conditions at the rate specified in the test plan.

(6) Visually examine the test item to the extent possible and conduct an operational checkout IAW the test plan. Document the results.

(7) If appropriate, stabilize the test item to the required high test temperature and ambient pressure.

(a) With the test item non-operating, ramp the chamber temperature from room ambient conditions up to the maximum storage/transit test temperature. Perform this temperature ramp at the maximum allowed rate of change. Two visual examples are presented in Appendix A to describe: (1) a ramp from ambient temperature to a high-test temperature (Figure A-5) and (2) a diurnal high temperature test cycle (Figure A-6). These examples are presented as information only.

(b) Allow the test item to soak at the maximum storage/transit test temperature until it has reached thermal stabilization or for 2 hours, whichever is shorter.

(8) Ramp the chamber from the site ambient pressure to the storage/transit low-test pressure (altitude). Perform the pressure ramp at the maximum altitude rate of change unless otherwise specified in the test plan. A visual example of a typical pressure test plot is presented

in Appendix A, Figure A-2. Note: Chamber pressure and temperature can be varied as required in the test plan either independently or dependently.

(9) Maintain the high temperature and low-pressure conditions until the test item has reached thermal stabilization or 4 hours, whichever is shorter, unless otherwise specified in the test plan.

(10) Adjust the chamber from the test temperature and test pressure to standard ambient conditions at the rate specified in the test plan.

(11) Visually examine the test item to the extent possible and conduct an operational checkout IAW the test plan. Document the results.

c. Execute an operational test procedure.

(1) Place the test item in its operational configuration within the test chamber.

(2) If appropriate, stabilize the test item to the required low test temperature. If not appropriate, skip to paragraph 4.3.2c(7).

(a) With the test item non-operating, ramp the chamber temperature from room ambient conditions down to the minimum operating test temperature. Two visual examples are presented in Appendix A to describe: (1) a ramp from ambient temperature to a low test temperature (Figure A-3) and (2) a diurnal low temperature test cycle (Figure A-4). These examples are presented as information only.

(b) Allow the test item to soak at the minimum operating test temperature until it has reached thermal stabilization or for 4 hours, whichever is shorter.

(c) Operate the test item at its minimum operating voltage (minimum functions powered). If supplemental cooling (or heating) is supplied during this step, tailor cooling or heating parameters for minimum heat removal (e.g., minimum temperature and minimum flow for air cooling at or above the minimum operating temperature). Maintain this condition for the minimum specified warm-up period.

(d) Perform a performance check immediately following step 4.3.2c(2)(c) above to verify the test item operates as required.

(3) With the test item operating, ramp the chamber from the site ambient pressure to the operating low-test pressure (altitude). Perform the pressure ramp at the maximum altitude rate of change unless otherwise specified in the test plan. A visual example of a typical low-pressure

test cycle is presented in Appendix A, Figure A-2. Note: Chamber pressure and temperature can be varied as required in the test plan independently or dependently.

(4) Maintain the conditions for a minimum of one hour unless otherwise specified in the test plan.

(5) Ramp the chamber test temperature and test pressure to standard ambient conditions at the rate specified in the test plan. Return the test item to a non-operating condition and discontinue the supplemental cooling at the conclusion of the ramp.

(6) Visually examine the test item to the extent possible and conduct an operational checkout IAW the test plan. Document the results.

(7) If appropriate, stabilize the test item to the required high test temperature and ambient pressure.

(a) With the test item non-operating, ramp the chamber temperature from room ambient conditions up to the maximum operating test temperature. Perform this temperature ramp at the maximum allowed rate of change. Two visual examples are presented in Appendix A to describe: (1) a ramp from ambient temperature to a high-test temperature (Figure A-5) and (2) a diurnal high-temperature test cycle (Figure A-6). These examples are presented as information only.

(b) Operate the test item at its maximum operating voltage (all required equipment powered). At the same time, supply supplemental cooling at the worst case thermal conditions, e.g., maximum temperature and minimum flow for air cooling.

(c) Allow the test item to soak at the maximum operating test temperature until it has reached thermal stabilization or for 2 hours, whichever is shorter.

(d) Perform a performance check immediately following step 4.3.2c(7)(c) above to verify the test item operates as required.

(8) With the test item operating, ramp the chamber from the site ambient pressure to the operating low-test pressure (altitude). Perform the pressure ramp at the maximum altitude rate of change unless otherwise specified in the test plan. A visual example of a typical low pressure test cycle is presented in Appendix A, Figure A-2.

(9) Maintain the high-temperature and low pressure conditions until the test item has reached thermal stabilization or 4 hours, whichever is shorter, unless otherwise specified in the

test plan. Note: Chamber pressure and temperature can be varied as required in the test plan independently or dependently.

(10) Perform a performance check to verify that the test item operates as required.

(11) Ramp the chamber test temperature and test pressure to standard ambient conditions at the rate specified in the test plan. Return the test item to a non-operating condition and discontinue the supplemental cooling at the conclusion of the ramp.

(12) Visually examine the test item to the extent possible and conduct an operational checkout IAW the test plan. Document the results.

d. Execute a post-test standard ambient checkout.

(1) Adjust the chamber test pressure and test temperature to standard ambient conditions at the rate specified in the test plan.

(2) Conduct a visual examination of the test item with special attention to stress areas and document the results.

(3) Conduct an operational checkout as described in the test plan and document the results.

(4) Secure the test item and remove it from the test chamber IAW the test plan.

4.3.3 Repeat the above procedural steps, paragraphs 4.3.2a through 4.3.2d, as appropriate to perform a multiple cycle test IAW the test plan. Document the results.

5. DATA REQUIRED.

5.1 Document all sensor and transducer readings throughout the test period.

5.2 Information to be documented.

a. Pre-test documentation. Include the following:

(1) Test facilities and instrumentation.

(2) Required test procedures executed under the test plan.

(3) Type, location, and use of critical components, if applicable.

(4) Test item configuration (storage/transit or operational).

(5) Test duration.

(6) Location of sensors, e.g., thermocouples and transducers.

(7) Test item installation details (including mounting provisions, orientation, interconnections, etc.).

(8) Cooling provisions, if appropriate.

(9) Test altitude.

(10) Altitude rate of change.

(11) Test temperature (if other than standard ambient).

(12) Test item nomenclature (manufacturer, serial number, etc.)

(13) General appearance/condition of the test item.

(14) Specific physical anomalies detected during visual examination.

(15) Environmental test history of the specific item.

(16) All pre-test data from the functional parameters that will be monitored during and after the main procedures.

b. <u>During test documentation.</u> Include the following:

(1) Document performance data of the test item sufficient to perform suitable tests/analyses to determine if the test exposure produces changes in test item performance when compared with pre-test data.

(2) Document a continuous record of environmental conditions applied to the test item.

(3) Maintain a record of test item response to applied environmental forcing functions.

(4) Test interruptions and resolution, procedures used, and notes. Include undertest, overtest, and other out-of-tolerance instances.

(5) Other test anomalies, e.g., power outages, equipment non-performance, test conductor procedural changes.

c. Post-test documentation. After completing each environmental test, examine the test item IAW the materiel specifications. Operate the test item, when appropriate for obtaining post-test data. Compare the results with data acquired and documented in the pre-test and during test periods. Include the following:

(1) Test item nomenclature (manufacturer, model/serial number, etc.).

(2) Test equipment identification including accessories.

(3) The actual test sequence (cycling or independent tests) used.

(4) Deviations from the planned test program including explanation.

(5) Performance data collected on the same parameters at the same operational levels as those of the pre-test including visual examination results, and photographs, if applicable.

(6) Temperature and pressure versus time data.

(7) Other data specified in individual methods or requirements document(s).

(8) Previous test procedures to which the specific test item has been subjected.

(9) Initial failure analyses.

(10) A signature and date block for the test engineer/technician to certify the test data.

6. PRESENTATION OF DATA.

a. Test data, both raw and processed, shall be properly marked for identification and correlation with the test item. Pre-test, test and post-test data shall be included. Test personnel shall include their opinions concerning success or failure of the test. When a failure occurs, it is important to note the conditions of failure; i.e., when, what, and how the item failed. Tabulation of data provides an easy method for viewing the whole testing process, an example of which is shown in Table 2.

b. For standardization purposes, data plots capable of being read with a resolution within 2 percent of full scale and digital data hard copy capable of presenting data with a resolution of at least two decimal places should be used.

c. Deterioration or changes in performance of any components which can in any way prevent the test item from meeting functional maintenance and service requirements during service life shall provide reason to consider the test item as having failed to comply with the item requirements.

TABLE 2. DATA COLLECTION WORKSHEET

Item Identification	Flight Termination Receiver, Model 21A, SN21
Level of Assembly	Unit
Failure Type	Workmanship - Short in Lead
Time of Failure	1015, 10 January 2002
Type Test Failed	High Temperature - Altitude
Reason For Failure	Loss of Signal Due to Power Failure
Failed Component & Location	DC-DC Converter, Card #2, Left Edge
Vendor's Name	Power Systems, Inc.

APPENDIX A. ENVIRONMENTAL TEST INSTRUCTIONS SHEET EXAMPLE

An example of an environmental test instruction sheet is provided. Note the format. This form may be adapted to accommodate any test center. The example illustrates a temperature-altitude (low-pressure) test. Figure A-1 presents an example of transducer locations on a test item; Figure A-2 presents an example of a low-pressure test profile; and Figures A-3 through A-6 present examples of an ambient to low-temperature ramp, a 24-hour diurnal low-temperature cycle, an ambient-to high-temperature ramp, and a 24-hour diurnal high-temperature cycle, respectively. The latter four-example temperature profiles may be combined with one or more low-pressure profiles in order to tailor the particular test requirements.

ENVIRONMENTAL TEST INSTRUCTIONS

Test Engineer: John Doe	**Date:** 2 January 2002
1. Project/Test Title: Missile Low Temperature-Altitude (Low Pressure) Test	
2. TRMS #:	**JONO:** **WO:**
3. Test Location: Low Pressure Test Facility	**TDY:** N/A

4. Required Test Equipment

Temperature-altitude (low pressure) test chamber with temperature and pressure logging equipment.

5. Test Item Classification

Restricted ***Unclassified*** Classified
Sensitive Confidential Secret Top Secret

6. Test Data Classification

Unclassified Classified
Sensitive Contractor Sensitive Other

7. Test Schedule Information

Item Delivery Date: 8 Jan 02 Test Start Date: 8 Jan 02 Test Completion Date: 12 Jan 02	**Special Information**

8. Personnel Requirements

Full Time Part Time Roving Other

9. Test Item Hazardous Information

N/A Hazardous Duty Pay Authorized	GS 1/17 WG 51/06

**This item is non-hazardous.

10. Approvals

Section Chief Concurrence	**Test Engineer**	**Customer Concurrence**

DTC-WS-ST-AA FORM 80 **PREVIOUS EDITIONS ARE OBSOLETE** **2 JAN 02**

11. Instrumentation Requirements

a. Instrumentation Type Requirements: 5 type **T** thermocouples (TC) and 1 pressure transducer.

b. Instructions: A diagram showing approximate instrumentation locations is attached (Figure A-1). All TC and pressure readings are to be logged every 1 minute. The pressure transducer will be installed in the chamber center.

c. Instrumentation Locations:

TC # 1.	Chamber control air	Pressure # 1: Chamber
2.	Radome skin	
3.	Guidance skin	
4.	Warhead (inert) skin	
5.	Motor skin	

12. Over/Under Temperature Safety Setting Requirements

Over-Temp Chamber Safety set to: N/A	Under-Temp Chamber Safety set to: -47°C (-53°F)

13. Test Instructions

1. The test item will be placed into the chamber in an operational configuration. The test item will be instrumented (see Figure A-1) IAW the test plan. The air pressure will be ambient conditions.

2. The chamber air temperature will be ramped to the temperature of -45.5°C (-50°F). The temperature rate of change will not exceed 2.2°C (5.4°F) per minute during any temperature change. The temperature tolerance will be ±1.2°C (3°F) unless otherwise stated. The chamber air temperature will be maintained for a minimum of 2 hours after the skin thermocouples stabilize (stabilization constitutes a temperature rate of change less than 0.8°C (2°F) per hour).

3. After stabilization has occurred, the chamber air pressure will be ramped to the transit altitude pressure of 1.8 kPa (90,000 ft) while maintaining the chamber air temperature at -45.5°C (-50°F). Pressure rate of change will not exceed 10 m/s (2,000 ft/min). These conditions will be maintained for a minimum of 1 hour.

4. The test item will be operational from 69.7 kPa (10,000 ft) to the conclusion of the test.

5. Once the 1-hour period is completed, ramp the chamber air pressure to the ambient air pressure.

6. Once the chamber air pressure is at ambient, ramp the chamber air temperature to ambient and allow the test item to stabilize. Perform an operational test IAW the test plan.

Test Engineering Data Requirements:

a. All important test events, exposure time, equipment problems, time on and off for operators, phone calls to test engineer, etc.

b. Test Control Tolerance: Temperature: ±1.2°C (3°F); Pressure : ±10% of reading.

Additional Test Instructions (See Attached Sheet) None

14. Emergency Instructions

Person to Notify (In Order)	Work Phone	Home Phone
John Doe	678-1234	521-4321
John Doe #2	678-5678	707-8765

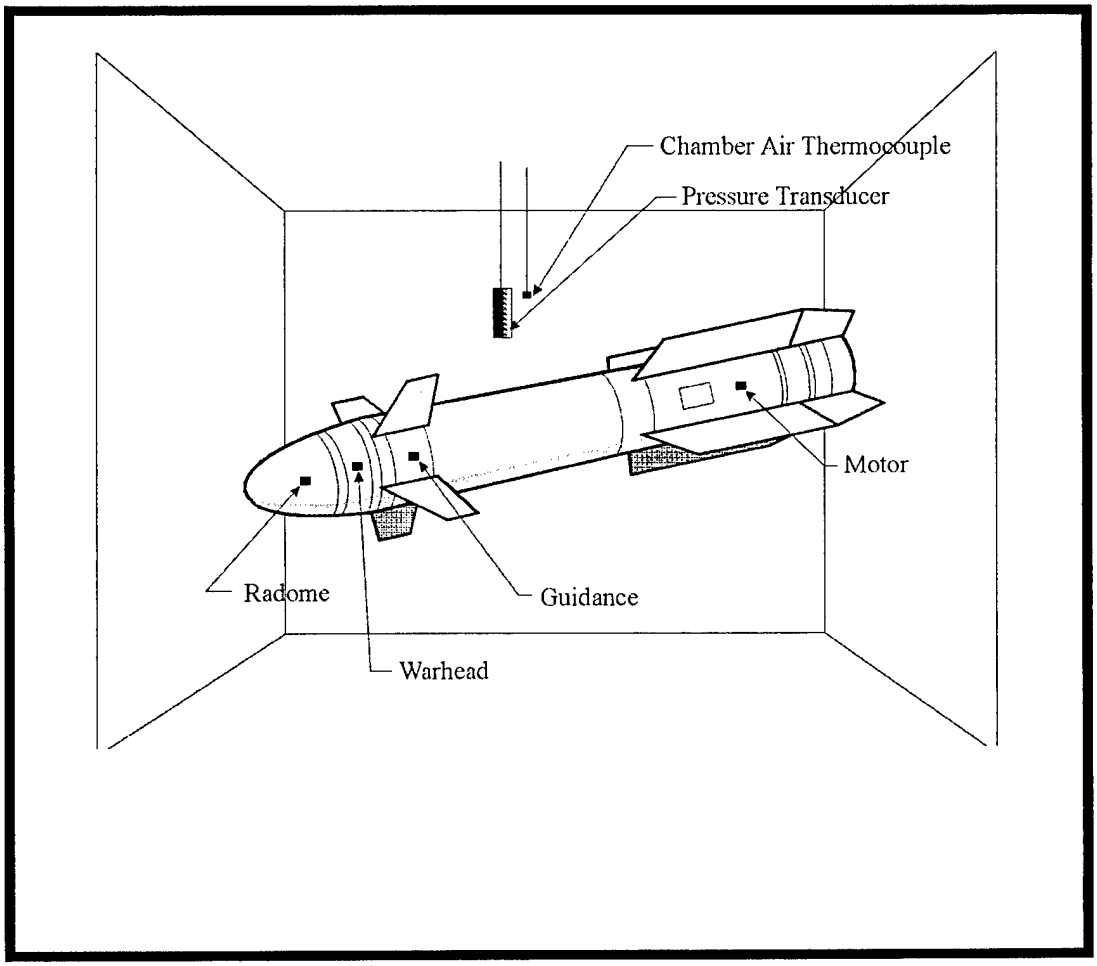

Figure A-1. Transducer Locations (1-Pressure and 5-Thermocouple) on Test Item

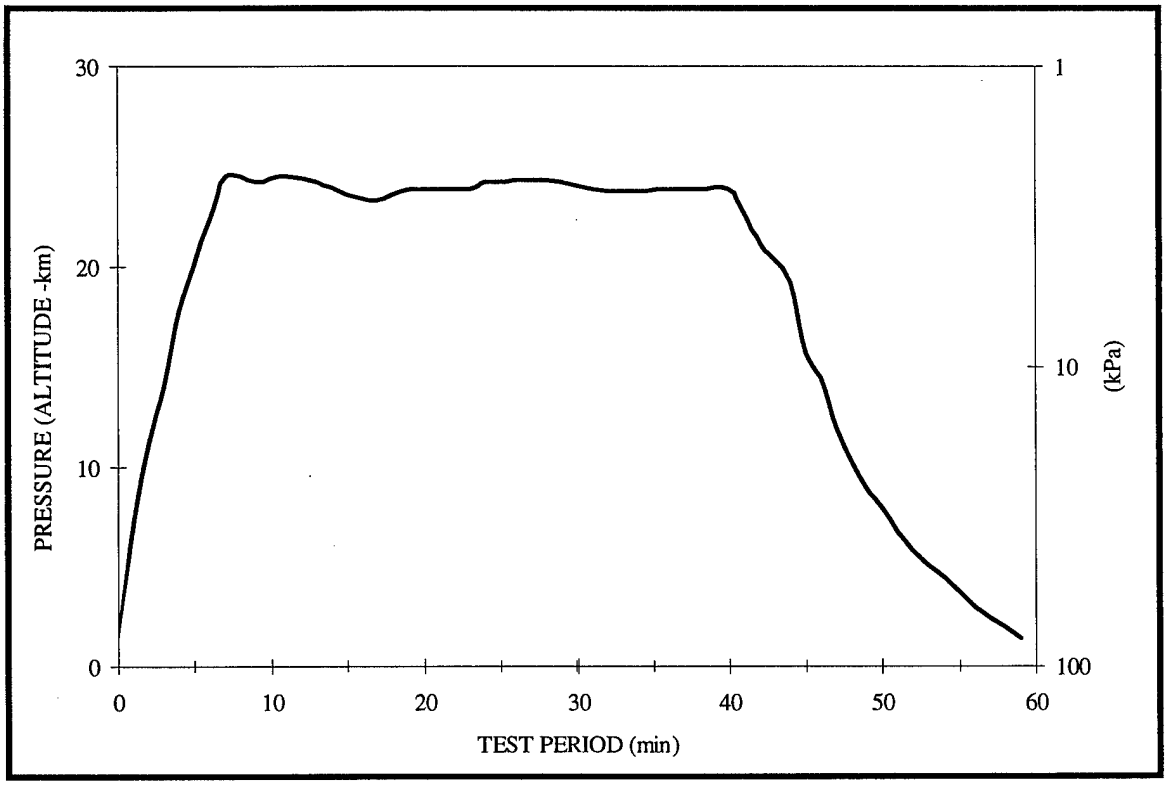

Figure A-2. Example of a Typical Low-Pressure Test Cycle

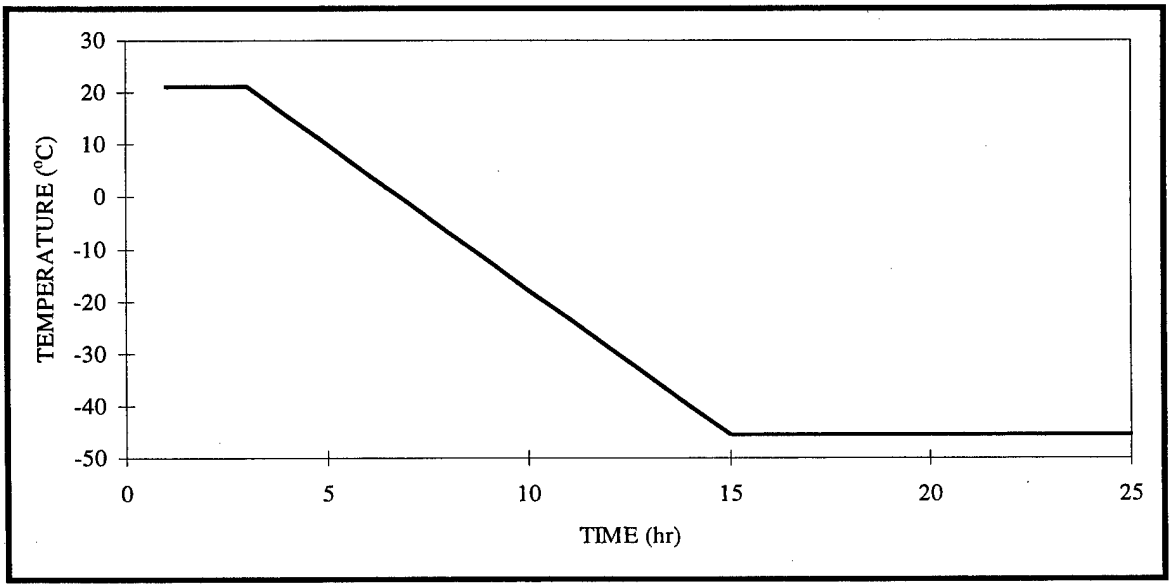

Figure A-3. Example of a Ramp from Ambient Conditions to a Low-Test Temperature Level

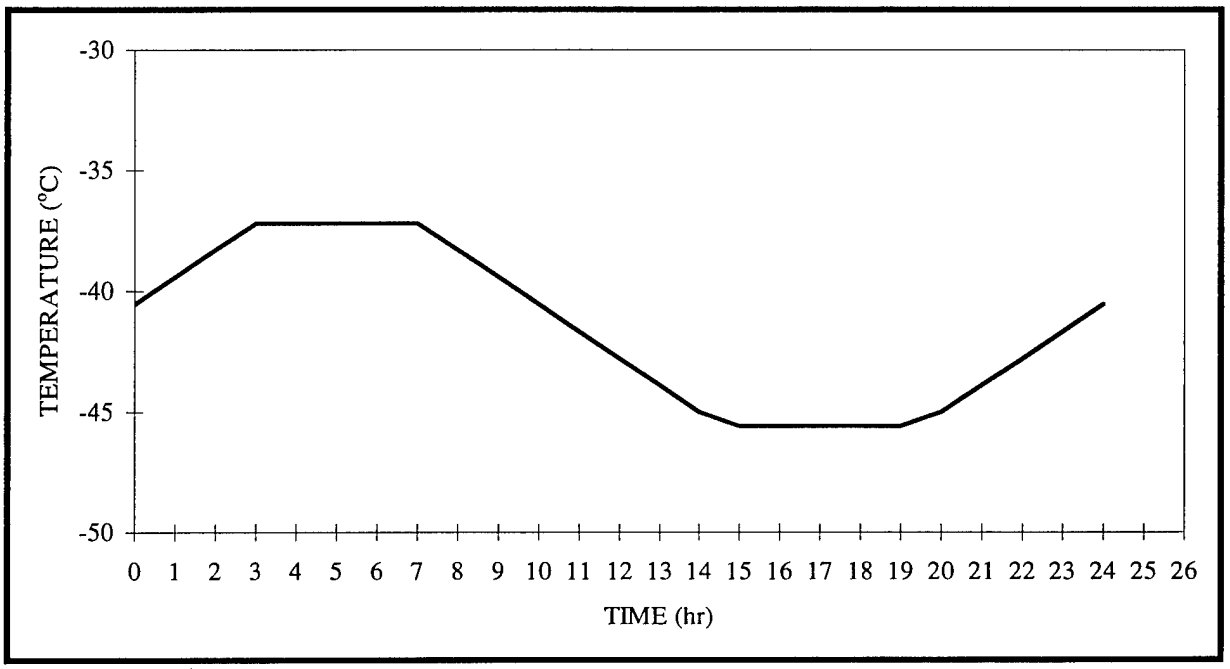

Figure A-4. Example of a Low-Temperature Diurnal Cycle

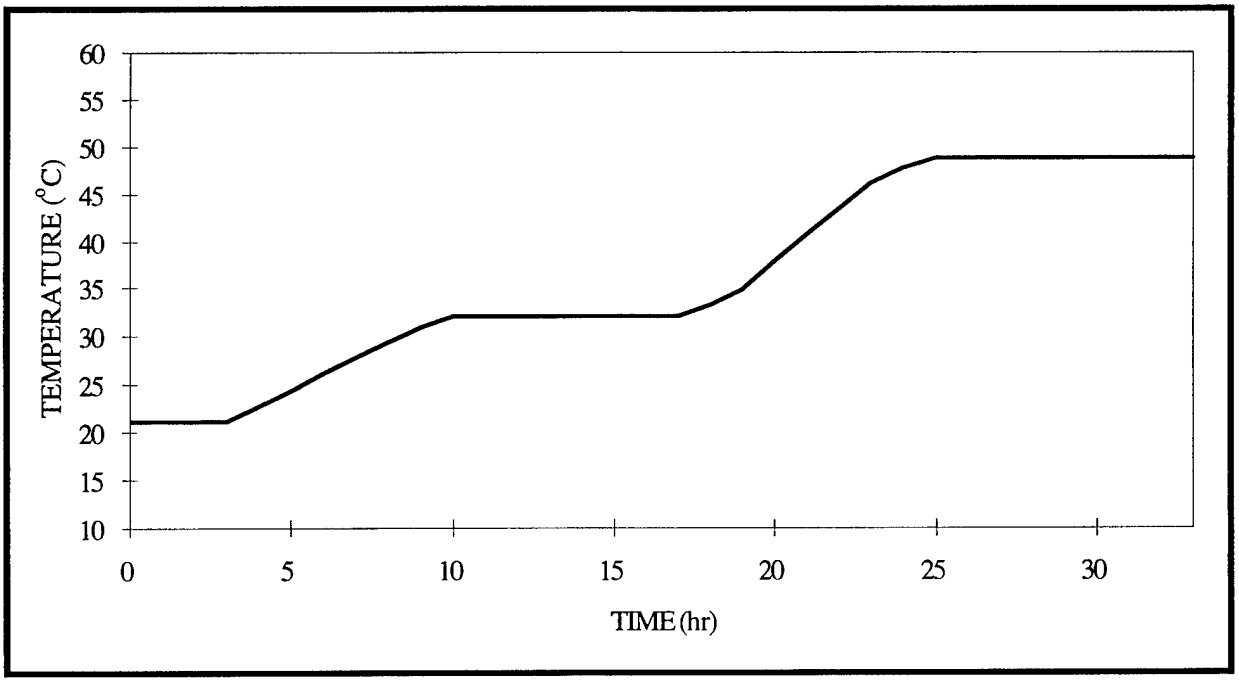

Figure A-5. Example of a Ramp from Ambient Conditions to a High-Test Temperature Level

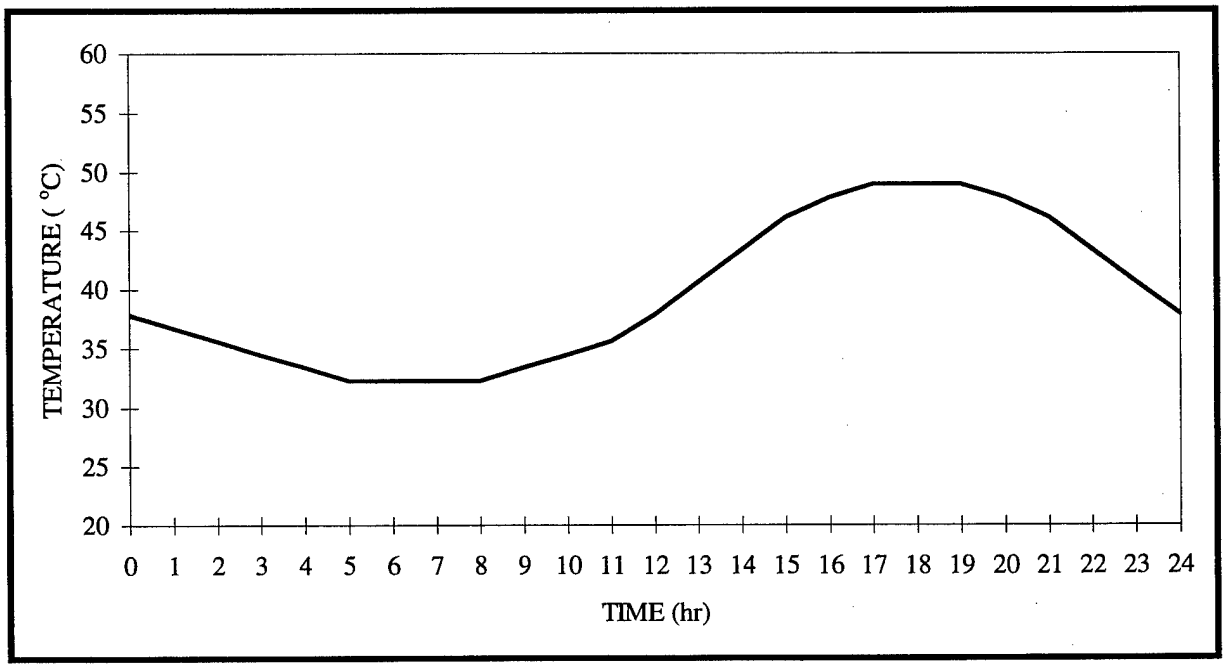

Figure A-6. Example of a High-Temperature Diurnal Cycle

APPENDIX B. TEST SEQUENCE AND PROCEDURE EXAMPLES

An example of a test sequence plan of varying chamber conditions (refer to Table B-1(a & b)) is included for information only. Two detailed test procedures are presented as examples.

Additional data are presented in Figures B-1 through B-4. These figures describe the data that was used to generate Table B-1. The figures are separated into four classes of equipment each presenting the temperature-altitude envelopes for continuous and intermittent operation design and test requirements. Figures B-3 and B-4 also include a category that describes the design and test requirements for short-time operations. The indicated classes are used for illustrative purposes only as noted in paragraph 3.1. The sequence steps in Table B-1 are representative test parameters, which may be selected when preparing a specific test procedure.

B-1. EXAMPLE TEST PROCEDURES.

B-1.1 Example Test No. 1 (Class 1, Sequence Step 4)

a. Adjust the chamber temperature to and stabilize it at the temperature specified in sequence step 4 of Table B-1(a) while maintaining local barometric pressure.

b. Open the test chamber door long enough for frost to form on the test item and then commence to melt. Do not leave the chamber door open long enough to allow the melt to evaporate. If the relative humidity is such that frost will not form, an artificial means shall be used to provide the relative humidity necessary to form frost.

c. Close the test chamber door and turn on the test item using the item's normal operating parameters and document all operating parameters specified in the test item's test plan. The test item shall operate satisfactorily within the specified warm-up time. If the time required to check the test item exceeds the warm-up period by 15 minutes or more, the check shall be halted prior to the 15-minute time period. The chamber shall be opened then closed to return it to a frost-melt condition, and the operational check shall be continued.

d. At the completion of the operational check, turn off the equipment.

e. Repeat steps (a) through (d) until the test item has been operationally checked a total of three times.

f. Visually inspect the test item.

TABLE B-1(a). EXAMPLE TEST CHAMBER CONDITIONS FOR TEMPERATURE-ALTITUDE TESTS, STEPS 1-7

CLASS	SEQUENCE >	1	2	3	4	5	6	7
1	TEMP ALT (m) (kPa) TIME	-62°C ATM P* 2 Hrs	-54°C ATM P	-54°C 15,240	-10°C ATM P	85°C ATM P 16 Hrs	55°C ATM P 4 Hrs	71°C ATM P 30 Min
2	TEMP ALT (m) (kPa) TIME	-62°C ATM P 2 Hrs	-54°C ATM P	-54°C 21,335 4.4	-10°C ATM P	95°C ATM P 16 Hrs	71°C ATM P 4 Hrs	95°C ATM P 30 Min
3	TEMP ALT (m) (kPa) TIME	-62°C ATM P 2 Hrs	-54°C ATM P	-54°C 30,500 1.1	-10°C ATM P	150°C ATM P 16 Hrs	95°C ATM P 4 Hrs	125°C ATM P 30 Min
4	TEMP ALT (m) (kPa) TIME	-62°C ATM P 2 Hrs	-54°C ATM P	-54°C 30,500 1.1	-10°C ATM P	200°C ATM P 16 Hrs	125°C ATM P 4 Hrs	150°C ATM P 30 Min

* ATM P = Atmospheric pressure at the test site

TABLE B-1(b). EXAMPLE TEST CHAMBER CONDITIONS FOR TEMPERATURE-ALTITUDE TESTS, STEPS 8-14

CLASS	SEQUENCE >	8	9	10	11	12	13	14
1	TEMP ALT (m) (kPa) TIME	OMIT	30°C 12,191 18.8 4 Hrs	47°C 12,191 18.8 30 Min	20°C 15,240 11.6 4 Hrs	35°C 15,240 11.6 30 Min	OMIT	AMB**
2	TEMP ALT (m) (kPa) TIME	OMIT	48°C 15,240 11.6 4 Hrs	60°C 15,240 11.6 30 Min	10°C 21,335 4.4 4 Hrs	35°C 21,335 4.4 30 Min	OMIT	AMB
3	TEMP ALT (m) (kPa) TIME	150°C ATM P	36°C 15,240 11.6 4 Hrs	90°C 15,240 11.6 30 Min	20°C 30,500 1.1 4 Hrs	50°C 30,500 1.1 30 Min	75°C 30,500	AMB
4	TEMP ALT (m) (kPa) TIME	150°C ATM P 10 Min	90°C 15,240 11.6 30 Min	115°C 15,240 11.6 30 Min	50°C 30,500 1.1 4 Hrs	75°C 30,500 1.1 30 Min	155°C 30,500 1.1 10 Min	AMB

** AMB = Ambient site conditions

B-1.2 Example Test No. 2 (Class 1, Sequence Step 10)

a. Adjust the chamber temperature to and stabilize it at the temperature specified in sequence step 10 of Table B-1(b) while maintaining local barometric pressure.

b. Turn on the test item.

c. Adjust the chamber pressure to simulate the altitude specified in sequence step 10 of Table B-1(b).

d. Operate the test item at its normal operating parameters for the time indicated in sequence step 10 and document all operating parameters specified in the test item's test plan.

e. At the completion of the specified operating period turn the equipment off for a period of 15 minutes.

f. Repeat steps (b) through (e) at the specified chamber temperature-altitude conditions specified in sequence step 10 of Table B-1(b) until a total of four operating periods have been run.

g. Document the test item temperature in 10-minute intervals during each operating period.

h. At the completion of the fourth operating period, turn off the equipment.

i. Visually inspect the test item.

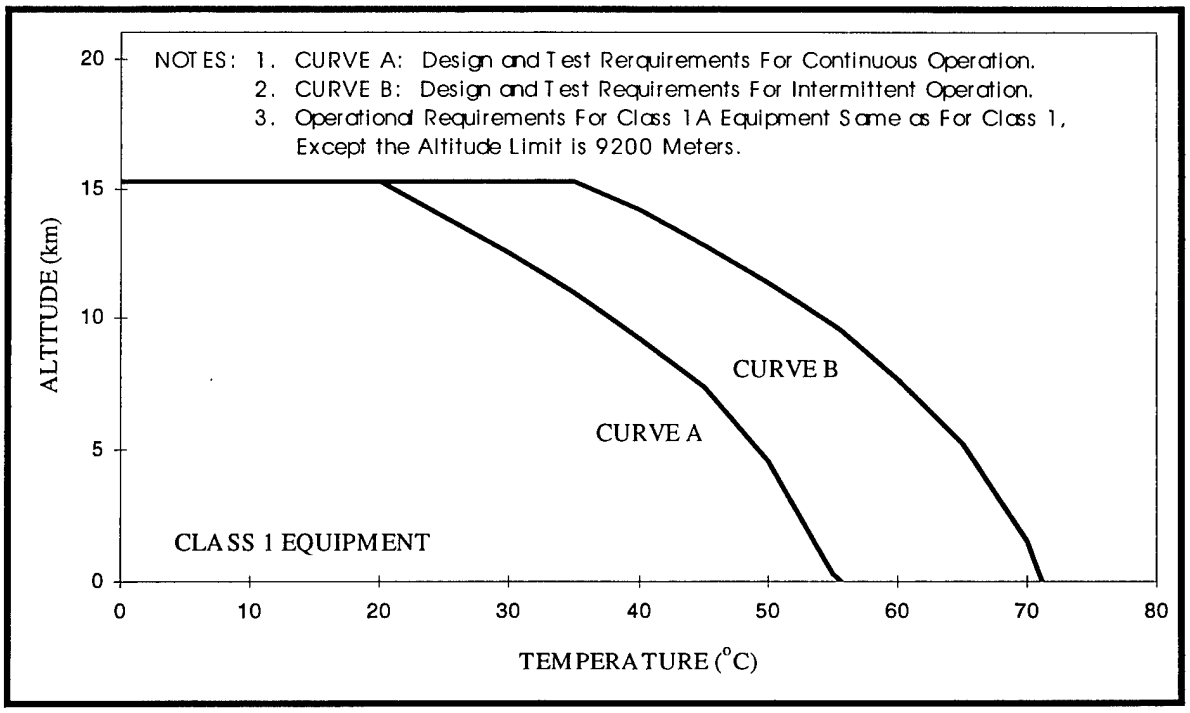

Figure B-1. Operational Planning Requirements for Class 1 Aerospace Equipment, Temperature versus Altitude

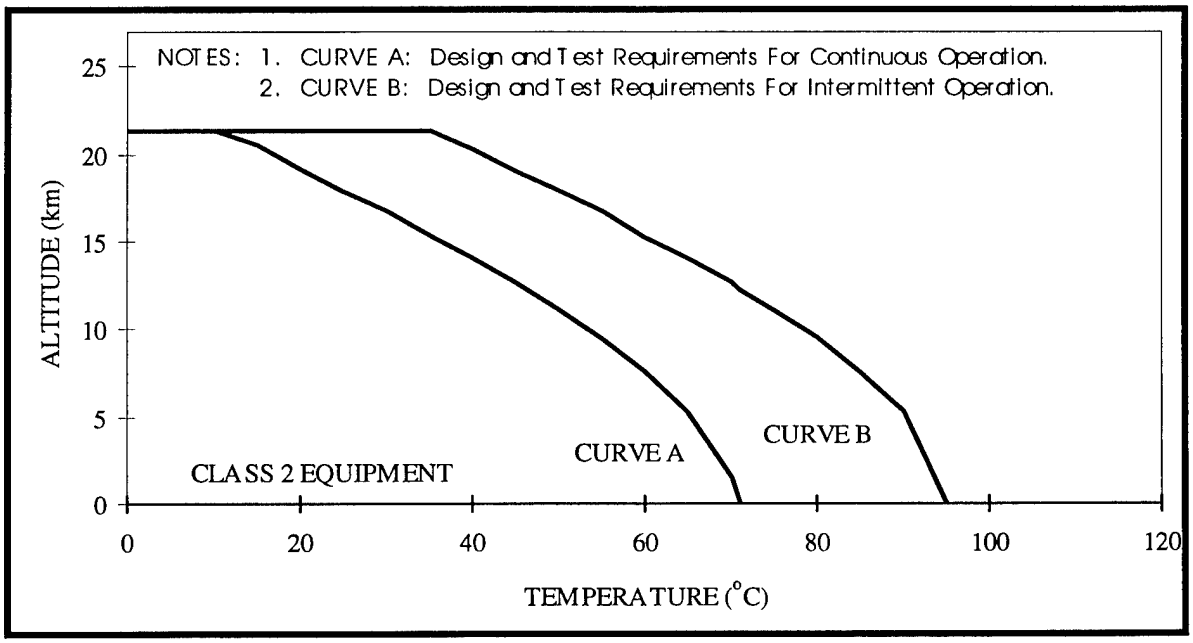

Figure B-2. Operational Planning Requirements for Class 2 Aerospace Equipment, Temperature versus Altitude

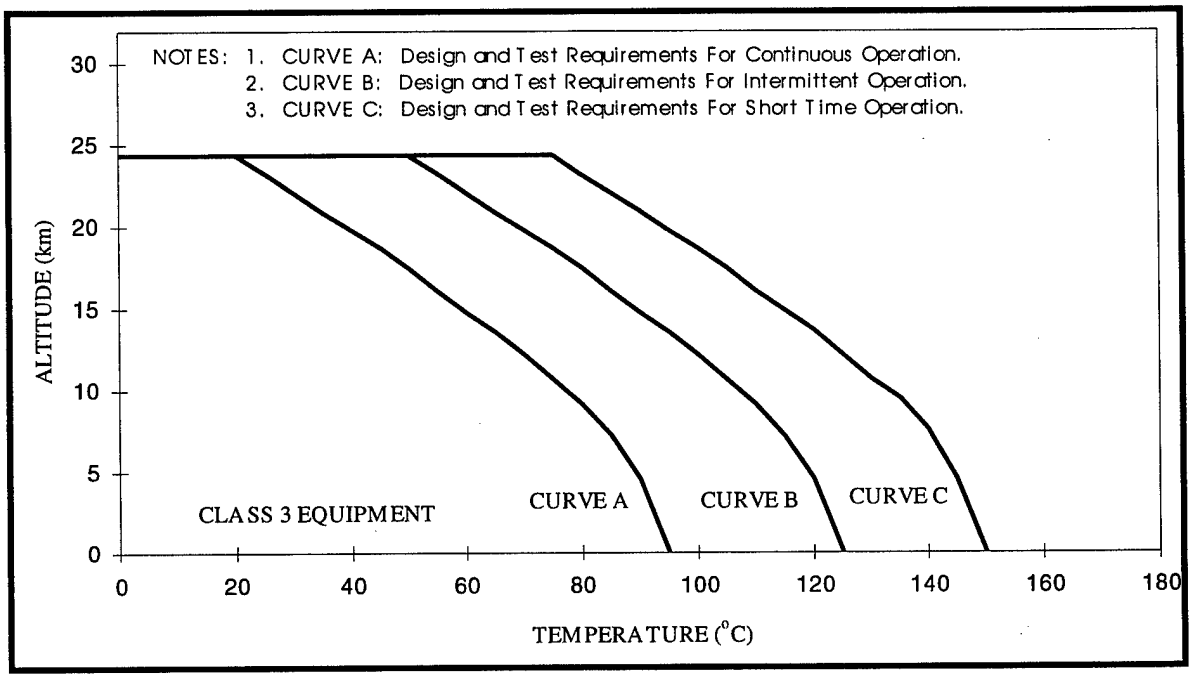

Figure B-3. Operational Planning Requirements for Class 3 Aerospace Equipment, Temperature versus Altitude

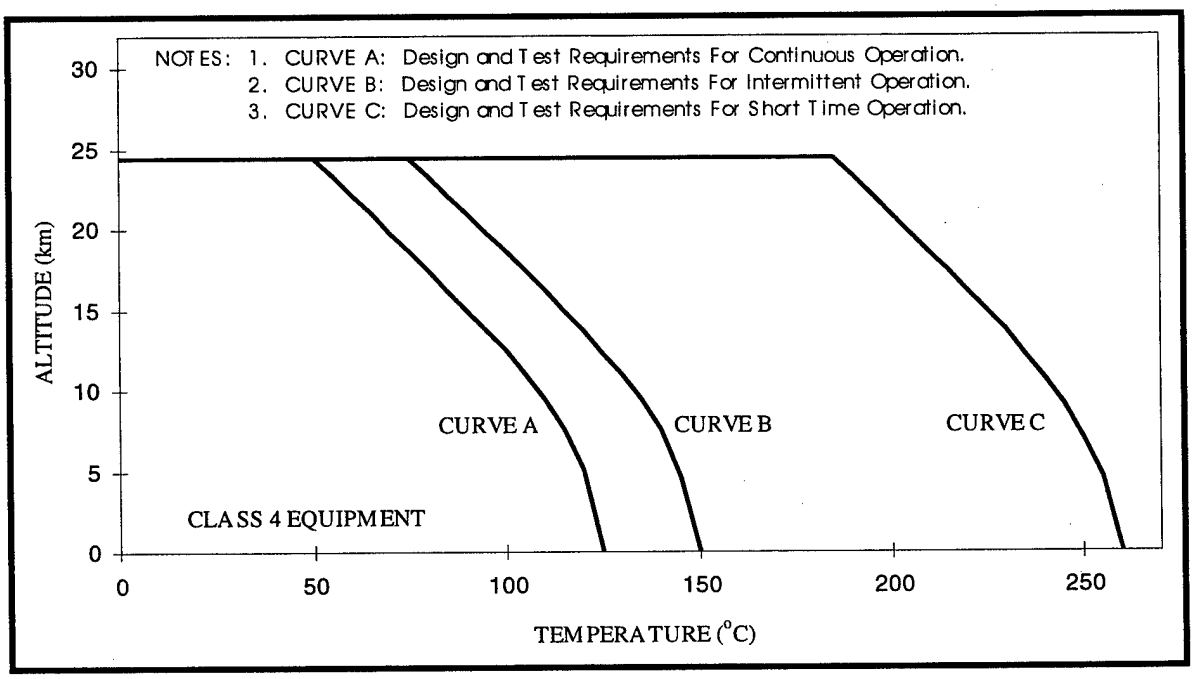

Figure B-4. Operational Planning Requirements for Class 4 Aerospace Equipment, Temperature versus Altitude

APPENDIX C. ALTITUDE VERSUS PRESSURE CONVERSION

Figure C-1 and the plot contained therein permits the reader to convert atmospheric pressure at any given altitude in meters to kPa. This formulation is provided to permit a more accurate determination if desired.

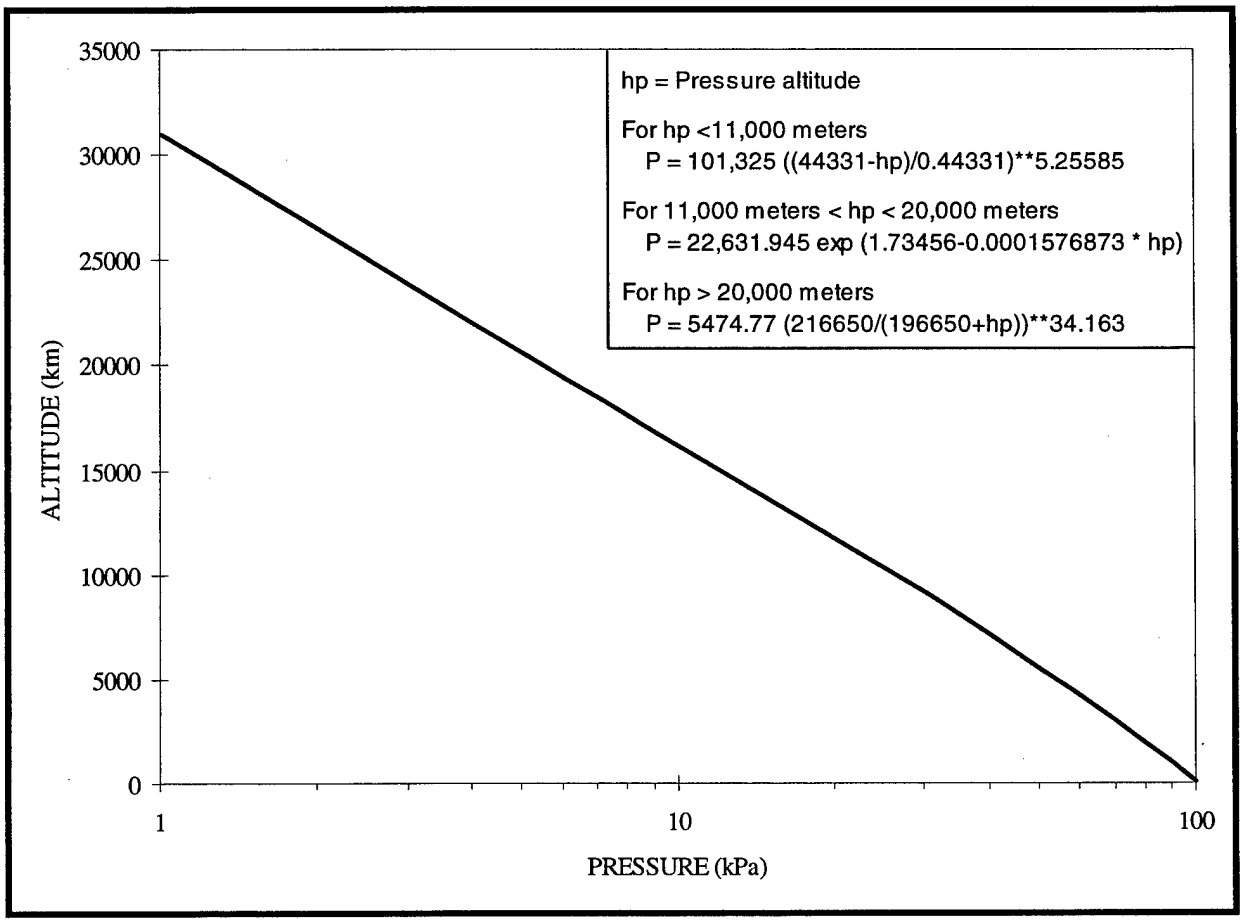

Figure C-1. Altitude versus Pressure Conversion Plot

APPENDIX D. REFERENCES

1. MIL-STD-810F, Environmental Engineering Considerations and Laboratory Tests, 1 January 2000.

2. MIL-STD-1540D, Product Verification Requirements For Launch, Upper-Stage, and Space Vehicles, 15 January 1999.

Recommended changes to this publication should be forwarded to Commander, U. S. Army Developmental Test Command, ATTN: CSTE-DTC-TT-M, Aberdeen Proving Ground, Md. 21005-5055. Technical information may be obtained from the preparing activity: Commander, U. S. Army White Sands Missile Range, ATTN: CSTE-DTC-WS-ST-AA, White Sands Missile Range, NM 88002-5157. Additional copies are available from the Defense Documentation Center, Cameron Station, Alexandria, Va. 22314. This document is identified by the accession number (AD No.) printed on the first page.